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POSITIVE CONDITIONED SUPPRESSION: TRANSFER OF PERFORMANCE BETWEEN CONTINGENT AND NON-CONTINGENT REINFORCEMENT SITUATIONS

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Five homing pigeons were trained on concurrent variable-interval schedules. A fixed-duration stimulus was occasionally presented on one key; and, in various conditions, this stimulus terminated (a) without reinforcement, (b) in noncontingent reinforcement, (c) with reinforcement contingent on a response on the key on which the stimulus was presented, and (d) with reinforcement contingent on a response on the key on which the stimulus was not presented. Initially, a stimulus terminating in noncontingent reinforcement generally produced decreased response rates on both keys during the stimulus. Contingencies, however, reliably produced increased rates during the stimulus on the key on which the contingency was arranged, relative to the rate on the concurrently available key. Contingency conditions were followed by noncontingency conditions in which the separation of rates caused by contingencies was maintained. When rates during the stimulus were compared with response rates on the same keys in the absence of the stimulus, contingency-caused rate increases and decreases were again found, but only the rate decreases were maintained in subsequent noncontingency conditions. Further data suggested that the contingency-caused rate changes were not maintained when the stimulus terminated without reinforcement, and that they were unaffected by a threefold decrease in the reinforcement rate provided by the baseline schedules. The results support the suggestion that performance in the positive conditioned suppression procedure results from concurrent and multiple schedule interactions. They further suggest that the production of either acceleration or suppression is dependent on adventitious and historical contingencies.

Key words: positive conditioned suppression, interactions, concurrent schedules, multiple schedules, superstition, pecking, pigeons

In the positive conditioned suppression procedure (Azrin & Hake, 1969; Henton & Brady, 1970; Meltzer & Brahlek, 1970; Smith, 1974), a distinctive stimulus is occasionally presented on an ongoing baseline reinforcement schedule, and the stimulus terminates in noncontingent reinforcement. Research has been reported which shows that the change in performance during the added stimulus is a function of the duration of the stimulus (Meltzer & Brahlek; Henton & Brady) and the baseline schedule reinforcement and response rates (Smith).

The considerations behind the present experiment were that the positive conditioned suppression procedure has elements of both Type 1 (Skinner, 1948) and Type 2 (Morse & Skinner, 1957) superstition procedures. Type 1 superstition is the maintenance of behavior by the adventitious delivery of free or response-noncontingent reinforcement. Type 2 superstition is the adventitious control of higher or lower response rates by a stimulus which has no function in signalling a change in reinforcement rate or response requirement. A further consideration is that both of these two types of superstition may operate to increase the rate of either a defined response or a response which is incompatible with the defined response.

This experiment set out to demonstrate the production of positive conditioned acceleration and suppression by making reinforcement contingent on a defined operant or contingent on an incompatible operant during an added signal. Such effects are, of course, well known from the study of concurrent and multiple

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schedule performance (Catania, 1966; de Villiers, 1977) in which increasing the reinforcement rate on one schedule or in one component decreases the response rate in the concurrently available or successively available performance. Such concurrent and multiple schedule interactions have recently been used by Stubbs, Hughes and Cohen (1978) to explain positive conditioned suppression data. Using rats, Stubbs et al. found that while a stimulus terminating in a contingent reinforcement did not reliably increase response rates, a stimulus terminating in noncontingent reinforcement reliably decreased response rates.

Parts of the present experiment are closely related to the research reported by Stubbs et al. (1978), except that here the baseline schedule was a 2-key concurrent variable-interval variable-interval (VI VI) schedule and the stimulus signaling added contingencies or noncontingent reinforcement occurred on only one key. There are two advantages of using a concurrent VI VI schedule as a baseline performance. First, concurrent schedule response rates are more sensitive to changes in reinforcement rates than are single schedule response rates (Catania, 1966); second, this schedule allows the assessment of the effects of an experimental procedure applied to one response on an alternative, incompatible response.

The second purpose of the present experiment was to determine whether response rate changes explicitly produced by added reinforcement contingencies would be maintained in subsequent conditions in which the reinforcement contingencies were no longer operative. Would contingency-produced performance changes be maintained as superstitious behavior?

METHOD

Subjects

Five homing pigeons were maintained at 80% ±15g of their free-feeding body weights by feeding mixed grain immediately after the daily training sessions. They were numbered 151, 152, 153, 155, and 156.

Apparatus

The sound-attenuated experimental chamber was situated remote from solid-state programming equipment and was provided with some masking noise from an exhaust fan. Inside the chamber were three response keys 2 cm in diameter, 11 cm apart, and 29 cm from the floor. The keys could be transilluminated various colors, but only the two outer keys were used in this experiment. Responses to lighted keys exceeding about .1 *N* operated microswitches and were followed by a feedback click from a relay inside the chamber. Responses to darkened keys were always ineffective. A grain hopper was situated below the center key and 9 cm from the floor. During reinforcement, which consisted of 3-sec access to wheat, the hopper was illuminated and the keylights were extinguished.

Procedure

Sessions were conducted at approximately the same time each day and terminated in blackout when a fixed number of reinforcements (varying between 35 when the baseline schedules were VI 120-sec and 8 or 12 when they were VI 360-sec) had been obtained.

As all the birds had extensive histories of responding on concurrent schedules, no keypeck or schedule training was required. They were placed directly on the first experimental condition.

The sequence of experimental conditions is shown in Table 1. In Condition 1, standard VI 120-sec schedules were arranged concurrently and independently on the outer two keys, which were illuminated white. A change-

Table 1

Sequence of experimental conditions and number of sessions training on each condition.

Condition	*Baselines (VI sec)*	*Red stimulus*	*Contingency on reinforcement terminating red*	*Sessions*
1	120	absent	—	54
2	120	present	no reinforcement	37
3	120	present	no contingency	26
4	120	present	key 1	31
5	120	present	no contingency	24
6	120	present	key 2	28
7	120	present	no contingency	28
8	120	present	no reinforcement	20
9	120	present	no contingency	28
10	360	present	no contingency	39[a]
11	360	present	key 2	32
12	360	present	no contingency	24
13	360	present	no reinforcement	21
14	360	present	key 1	36
15	360	present	no contingency	22

[a]The performance of bird 153 failed to stabilize in this condition.

over delay (Herrnstein, 1961) of 2 sec was arranged which specified that a response to one key could not be reinforced, even though a reinforcement had set up, until 2 sec had elapsed from the first response to a key after responding on the alternate key. These schedules, which we term the baseline schedules, were in effect in the first nine conditions.

In Condition 2, key 1 (the right key) was occasionally transilluminated red for 30 sec before reverting to white. The duration of the white-keys component between each red-key component averaged 120 sec. All the baseline reinforcement contingencies remained the same; that is, these reinforcements could be obtained on the two keys regardless of the key color. This was true for the baseline schedule through all subsequent conditions. In Condition 3, the red stimulus terminated in reinforcement which was delivered without any response being required, giving a standard positive conditioned suppression procedure save for the continuing availability of reinforcements on key 2.

In Condition 4, the reinforcement terminating the red component was maintained, but now it required a response to the red stimulus, after it had been present for at least 30 sec, for its production. Key 1 remained red until this reinforcement had been obtained. If, on the changeover from key 2 to key 1, both a baseline reinforcement and the red-terminating reinforcement were available, the sequence of events was: the 2-sec changeover delay was completed, the next key 1 response produced the baseline reinforcement, and, with key 1 still red, the next response produced the red-terminating reinforcement. Both keys then were white.

Condition 5 was the same as Condition 3, with the red-terminating reinforcement not response contingent. A contingency between responding and the red-terminating reinforcement was again arranged in Condition 6, but this time a response was required on key 2 after key 1 had been red for 30 sec. The procedure in this condition was exactly equivalent to that in Condition 4 if a baseline reinforcement was available on key 2 at the same time as a red-terminating reinforcement.

Subsequent conditions (Table 1) were similar to those already described. From Condition 10 to the end of the experiment, the baseline schedules were concurrent VI 360-sec VI 360-sec, but all other procedures remained the same.

Training was carried out on each experimental condition until a defined stability criterion had been met five, not necessarily consecutive, times by each bird. The criterion was that the median relative number of responses to the two keys in white over five sessions was not more than .05 different from the median of the five sessions preceding these. The number of sessions training on each condition is shown in Table 1.

RESULTS

The numbers of responses emitted per minute on the two keys when both were white and when key 1 was red are shown in Table 2 according to the sequence of conditions. In Condition 1, concurrent VI 120-sec schedules with no red key, the birds consistently responded at a higher rate on key 2, demonstrating a degree of bias between the responses. When the red key (with no associated reinforcement) was arranged in Condition 2, response rates in the white-keys components remained constant except for an increase in key 1 rate for Bird 153. The response rates on key 2 when key 1 was red were also similar to the rates on key 2 in the white-keys component in both Conditions 1 and 2. However, the rates on key 1 when it was red showed some large changes from the key 1 rates to the white key in Condition 1. The rate for Bird 151 fell to zero, and those for Birds 152, 153, and 155 increased.

The results show that when noncontingent reinforcement was delivered with the termination of the red-key 1 stimulus in Condition 3, the response rates on both keys during the red stimulus fell considerably with the only exception of Bird 156, for which the rate on key 2 dropped while the rate on key 1 showed a remarkable increase.

The reinforcement given at the end of the red stimulus was made contingent on a key 1 response in Conditions 4 and 14, and on a key 2 response in Conditions 6 and 11. We assume that, for pigeons, a contingency of this sort would increase the response rate on that key during the stimulus. Because the schedules are concurrently arranged, this same contingency would decrease the response rate on the other key. In every case, in these results,

Table 2

The number of responses per minute, averaged over the final five sessions for each bird in each experimental condition. One standard deviation is shown in parentheses.

		Both keys white		Key 1 red	
Condition	Bird	Key 1	Key 2	Key 1	Key 2
1	151	10(1)	24(3)		
	152	22(7)	46(11)		
	153	14(4)	16(3)		
	155	7(1)	19(3)		
	156	12(3)	17(3)		
2	151	12(3)	25(5)	0(0)	20(6)
	152	21(1)	44(6)	34(10)	52(8)
	153	29(4)	18(2)	31(6)	12(3)
	155	10(1)	21(1)	17(3)	17(4)
	156	18(3)	18(5)	14(2)	16(6)
3	151	17(6)	13(5)	0(0)	8(4)
	152	43(6)	47(7)	11(6)	18(2)
	153	16(6)	15(2)	8(3)	4(2)
	155	10(2)	17(3)	6(4)	1(1)
	156	25(4)	19(5)	52(9)	2(2)
4	151	16(8)	26(7)	31(7)	2(1)
	152	15(3)	30(6)	58(14)	32(6)
	153	18(3)	21(2)	33(3)	1(0)
	155	13(1)	16(2)	9(3)	3(2)
	156	30(4)	16(7)	62(6)	2(1)
5	151	6(2)	16(4)	24(8)	2(2)
	152	13(3)	54(5)	72(12)	10(4)
	153	22(2)	22(4)	19(9)	1(2)
	155	13(2)	12(3)	13(3)	1(1)
	156	36(6)	11(2)	54(9)	1(1)
6	151	11(2)	18(5)	21(4)	45(13)
	152	24(3)	41(4)	20(5)	47(7)
	153	18(3)	17(2)	12(4)	32(6)
	155	14(2)	18(3)	4(3)	33(4)
	156	41(1)	11(2)	19(3)	23(4)
7	151	2(0)	11(4)	16(5)	7(3)
	152	25(8)	42(12)	22(7)	48(4)
	153	18(4)	16(4)	7(5)	8(4)
	155	11(1)	18(1)	4(2)	20(3)
	156	35(2)	16(4)	61(5)	2(1)
8	151	4(2)	7(2)	18(5)	9(4)
	152	20(6)	47(10)	37(25)	44(10)
	153	22(6)	16(1)	21(3)	18(3)
	155	20(2)	10(2)	14(3)	16(2)
	156	38(3)	14(2)	28(3)	19(4)
9	151	2(1)	14(6)	16(6)	1(1)
	152	21(4)	46(8)	12(3)	46(7)
	153	24(4)	17(4)	10(6)	11(3)
	155	9(1)	17(1)	3(1)	16(3)
	156	41(11)	12(6)	58(14)	2(1)
10	151	3(5)	5(4)	20(7)	4(2)
	152	37(5)	36(6)	31(10)	41(7)
	153	22(3)	15(3)	9(3)	14(2)
	155	9(1)	7(2)	2(1)	5(1)
	156	43(2)	19(6)	41(5)	14(5)
11	151	4(4)	4(3)	5(3)	8(2)
	152	22(11)	25(8)	22(3)	57(22)
	153	12(3)	4(1)	5(2)	25(6)
	155	14(3)	5(1)	1(1)	17(4)
	156	23(8)	11(3)	4(1)	40(4)
12	151	2(1)	16(5)	19(6)	10(4)
	152	27(3)	21(5)	18(5)	24(4)
	153	18(6)	10(1)	6(3)	21(4)
	155	12(1)	6(2)	5(1)	7(8)
	156	33(2)	13(4)	17(11)	32(11)
13	151	2(1)	4(2)	5(4)	4(2)
	152	17(10)	15(13)	28(19)	29(16)
	153	11(3)	12(3)	15(6)	22(5)
	155	14(2)	10(1)	6(3)	12(4)
	156	27(6)	19(8)	28(12)	34(6)
14	151	1(0)	8(2)	25(7)	3(2)
	152	23(8)	34(15)	49(4)	15(8)
	153	7(2)	7(3)	16(5)	3(2)
	155	12(3)	6(1)	12(5)	6(2)
	156	26(2)	14(4)	51(3)	12(6)
15	151	0(0)	5(3)	12(4)	1(1)
	152	14(3)	28(3)	33(11)	22(2)
	153	7(2)	12(3)	16(4)	1(1)
	155	7(1)	16(2)	1(0)	18(2)
	156	22(3)	20(4)	40(3)	15(2)

response rates in the stimulus were higher on the key on which the contingency was arranged. This trend was not followed by the response rates in the white keys component; of the 20 comparisons, only 8 showed the same directional differences as the rates on the key 1 red component.

In the conditions immediately following those in which extra contingencies were added during the red stimulus, noncontingent reinforcement was arranged at the end of the red-key 1 component. The response rate differences in the red-key 1 component produced by the contingency were maintained in these conditions in 16 of the 20 possible cases (statistically significant on a Sign test at beyond $p = .05$). But again, there were no consistent differences in response rates in the white-keys component.

Conditioned suppression and acceleration are more often assessed as changes away from an ongoing baseline performance which is emitted successively to, rather than concurrently with, performance under an added stimulus-reinforcer contingency. For the present data, this requires the assessment of whether responding is higher in rate on a key in the presence of the red-key 1 stimulus than on that key when both keys were white. This was assessed according to which key the added contingency had been arranged on. In 19 of 20 cases, the response rate was higher in the presence of the stimulus on the key on which the contingency was added (significant on a Sign test at $p < .05$). The exception was Bird 155 in Condition 4. These rate differences were, however, not maintained in subsequent noncontingent reinforcement conditions with only 12 of the 19 possible cases showing differences in the expected direction. Response rates were significantly lower relative to the white-keys baseline on the key on which the contingency was not arranged (15 of 20 cases, Sign test, $p < .05$), and in 14 of these 15 cases this rate difference was maintained in subsequent noncontingent reinforcement conditions (Sign test, $p < .05$).

Conditions 8 and 13 were included to see whether the carryover of the response rate differences between the contingent and noncontingent conditions was controlled by the red stimulus alone or whether the provision of reinforcement was necessary. Condition 9, noncontingent reinforcement, was a control for any performance change obtained when reinforcement was not delivered (Condition 8). Thus, control over performance change by the noncontingent reinforcement would be shown by the same performance in Conditions 7 and 9 with a smaller difference in response rates in Condition 8. It would also be shown by response rates which were less different in Condition 13 (no reinforcement) than in Condition 12 (free noncontingent reinforcement). Both these indicators would also require that the noncontingent reinforcement Conditions (7 and 12) maintain the same difference in response rates as the previous contingent reinforcement conditions (6 and 11). Such was not the case for Bird 151 or for Bird 156 in Conditions 7 and 8. Thus, seven sequences of conditions remain in which reinforcement versus stimulus control can be investigated. The criteria mentioned above were met on both occasions by Birds 152 and 153, and on one occasion each by Birds 155 and 156. While six confirmations out of seven cases does not reach statistical significance on a Sign test, the data are largely consistent with control over behavior being exerted by reinforcement at the end of the key-1 red component.

The changes between noncontingent and no-reinforcement conditions were generally on key 1 responding (on which the stimulus was presented) with little change in key 2 responding. Furthermore, rate differences maintained in noncontingent conditions were generally replicated after exposure to no-reinforcement conditions.

The varied experimental conditions arranged in the key-1 red component appeared to have had no systematic effect on response rates in the white-keys component. The change from concurrent VI 120-sec to concurrent VI 360-sec baseline schedules in Condition 10 seemed generally to decrease response rates in the white-keys component with no systematic effect in the key-1 red component. The production of response rate changes by contingencies in the key-1 red component and their maintenance in subsequent noncontingent reinforcement conditions were also unaffected by the change in the baseline schedules.

DISCUSSION

The effects on performance of contingencies added at the termination of the key-1 red components were assessed relative to two different baselines. These were the rate on the key simultaneously available with the key on which the contingency was arranged (a "concurrent" measure) and the rate on the same key in the successively arranged white-keys component (a "multiple" measure). The present research showed that a stimulus terminating in a contingent reinforcement increased the response rate in the stimulus on the appropriate key on both measures and decreased the response rate on the concurrently available key. This result is consistent with our knowledge of multiple and concurrent schedule interactions in pigeons (Stubbs et al., 1978; de Villiers, 1977).

Following conditions in which added contingencies were arranged, conditions with stimuli terminating in noncontingent reinforcement were given. In these conditions, the acceleration and suppression in response rate produced in the previous conditions were maintained for a large number of sessions when measured according to the concurrently available baseline response rate. On successive schedule measures, suppression of responding was maintained, but acceleration was lost. The acceleration and suppression in response rates maintained during the stimulus under noncontingent reinforcement seemed to be controlled by the rereinforcement at the end of the key-1 red stimulus (Type 1 superstition: Skinner, 1948) rather than by the stimulus alone (Type 2 superstition; Morse & Skinner, 1957). Because the behavior change was clearly controlled by the key-1 red stimulus, both stimulus and reinforcement appear necessary for the acceleration and suppression effects during the key-1 red component. Stimulus superstitions were also not found when the key-1 red stimulus was first introduced (Condition 2) although our data did not reach statistical significance on this point. While this condition is the usual control condition for conditioned suppression experiments, it is the experimental condition for experiments on Type 2 superstition (Morse & Skinner).

Large performance changes were, however, evident in Condition 3 in which the key-1 red stimulus terminated in noncontingent reinforcement. The most common result was a decrease in response rate (Smith, 1974; Stubbs et al., 1978) on both keys during the key-1 red stimulus, although the performance of Bird 156 (a strong rate increase on key 1 and a decrease on key 2) is a notable exception. While a decrease in rate on both keys is consistent with an interpretation in terms of a general emotional state (Azrin & Hake, 1969), two factors argue against this: first, the performance of Bird 156 which showed a rate decrease on one key and a rate increase on the other key when key 1 was red in Condition 3 when noncontingent reinforcement was first introduced; second, the subsequent ready manipulation of suppression and the dissociation of suppression and acceleration between the two keys initially caused by contingencies and then maintained in conditions identical to Condition 3.

While the performance of Bird 156 in the first noncontingent reinforcement condition (3) was consistent with an autoshaping view of positive conditioned suppression (LoLordo, McMillan, & Riley, 1974), the suppression of rate shown by the other birds in the presence of key-1 red was not. Furthermore, both the maintenance of suppression in the key-1 red stimulus in noncontingent reinforcement conditions following contingent reinforcement conditions, and the general manipulability of suppression and acceleration, are arguments against LoLordo et al.'s autoshaping view.

There was no measurable contrast or induction caused by the contingencies arranged in the key-1 red component on the concurrent white-keys performance, although concurrent schedule interaction (or contrast) was clearly a feature of performance during the key-1 red component Table 2.

It appears, therefore, that conditioned acceleration or suppression is not a necessary result of the noncontingent positive conditioned suppression procedure. Which one of these two nominal performances occurs seems, in the present results, controlled by prior exposure to contingencies of reinforcement. In the response-contingent procedures, the production of acceleration and suppression was controlled by the location of the added contingent reinforcer as suggested by Stubbs, Hughes, and Cohen (1978). Using rats, these researchers found suppression of response rates in components which signaled added noncontingent reinforcers, and they suggested that it resulted from choosing between two incompatible responses. Adding noncontingent reinforcement decreased the response rate for the concurrently available contingent reinforcers on the baseline schedule. In the Stubbs et al. procedure, the responses emitted for the noncontingent reinforcer were necessarily inferred, whereas in the present experiment we placed direct contingencies on incompatible responses and measured the resulting rate changes of both responses. Our results certainly supported the Stubbs et al. interpretation. Our results differed in one minor way from those of Stubbs et al. We showed increases in response rates on a key in the presence of a signal terminating in contingent reinforcement, whereas Stubbs et al. found neither suppression nor acceleration. This difference probably relates to their use of a baseline VI 60-sec schedule on which the rats may have been responding at near-maximal rates.

Our argument is simply stated. The positive conditioned suppression paradigm is a set of weak, nondirective contingencies. While it is traditional in psychology to use nondirective contingencies for showing general states or natures (e.g., personality tests), these designs rest on the misapprehension that behavior in the absence of contingencies provides unadulterated data. On the contrary, the data are adulterated by adventitious and idiosyncratic behavior-reinforcement contingencies (Herrnstein, 1966) by behavioral drift (Herrnstein, 1966) and by idiosyncractic history or nurture. Once these adventitious correlations occur, laws concerning multiple and concurrent schedule interactions (de Villiers, 1977; Stubbs et al., 1978) will operate to amplify or dampen behavior changes. From this point of view, we would expect to see the known effects of stimulus duration (Shimp & Wheatley, 1971; Todorov, 1972) and of reinforcement rate (de Villiers, 1977; Neuringer, 1970). Added contingencies will also change the behavior; for example, a DRO (differential-reinforcement-of-other-behavior) schedule operating between behavior in the stimulus and the "noncontingent" reinforcer will likely produce suppression. Azrin and Hake (1969) used this procedure as therapy for two rats which showed accelerated response rates during a stimulus proceding noncontingent reinforcement. Both subsequently showed suppression. Based on the present research, it is our belief that, had the rats which "naturally" showed suppression been given DRH (differential-reinforcement-of-high-rate) therapy, they would have continued to show conditioned acceleration subsequently.

Our suggestion is that animals emit a great many behaviors in the usual experimental situation and that, depending on the schedules, stimulus durations and histories, any of these may be increased by adventitious reinforcement. Some may be compatible with the baseline operant, others will be incompatible. We believe that the situation in negative conditioned suppression is much the same, although the analysis here is hampered by a complete lack of data on shock-maintained superstitions. Historical contingencies do have an effect, as is shown by the effect of prior avoidance training on negative conditioned suppression (Herrnstein & Sidman, 1958). We should end with a plea that fewer potential controlling variables be left to chance operation. Weak nondirective contingencies are sensitive, but they may be more sensitive to the operation of adventitious contingencies than to the effects of emotional states.

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